



Boeing Technology
Phantom Works

Phantom

A System Dynamics Model of the Essential Tension Between Self-Synchronization and C2

CCRTS June 20 - 22, 2006
Bob Wiebe
Dan Compton
Dave Garvey



Report Documentation Page

*Form Approved
OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE JUN 2006	2. REPORT TYPE	3. DATES COVERED 00-00-2006 to 00-00-2006		
4. TITLE AND SUBTITLE A System Dynamics Model of the Essential Tension Between Self-Synchronization and C2			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Boeing ,Phantom Works,PO Box 2515,Seal Beach,CA,90740			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited				
13. SUPPLEMENTARY NOTES The original document contains color images.				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 34
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified		

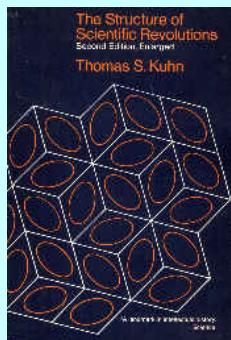
An Essential Tension Definition



Boeing Technology | Phantom Works

NCO Op's Analysis

In *Structure of Scientific Revolutions*, Thomas Kuhn characterized



"normal science" as current and generally accepted (traditional) research programs where new information is consolidated into existing theories
and

"revolutionary science" as new (innovative) research programs that emerge to cope with information that could not be assimilated into or accommodated by current research programs or theories

He states that science usually manifests an essential tension between tradition and innovation.

It is time to recognize that, if we are to be successful in meeting the 21st century challenges that we face, there will be major discontinuities between the Command and Control concepts and practices being taught and practiced today and those of tomorrow.

Dave Alberts, Dick Hayes: *Understanding Command and Control*, preface



Background Sources and Modeling

Boeing Technology | Phantom Works

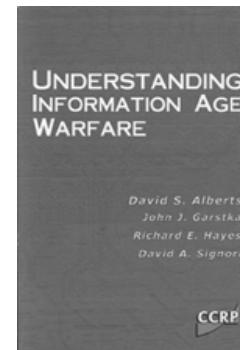
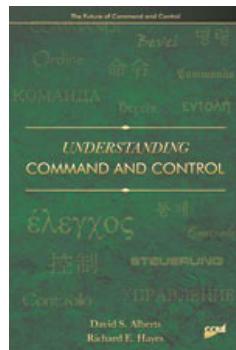
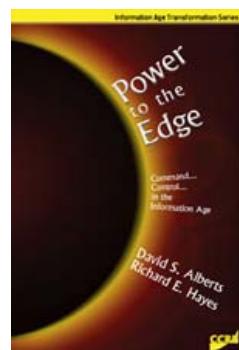
NCO Op's Analysis

Model Based on the CCRP books

Power to the Edge

Understanding Command and Control (Chapter 9)

Understanding Information Age Warfare



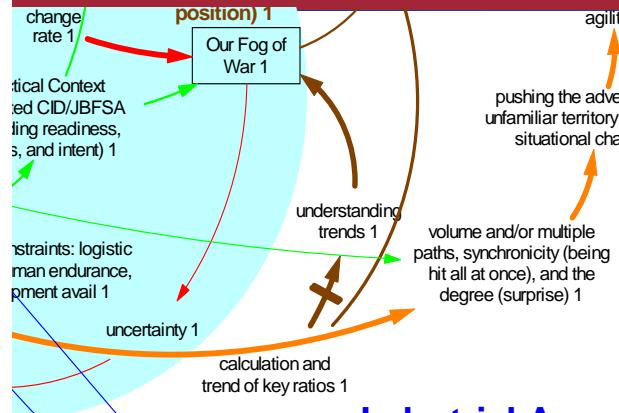
Syntheses and Model Building
Complex Systems Analysis and Simulations
Boeing Phantom Works





Essential Tension

Boeing Technology | Phantom Works

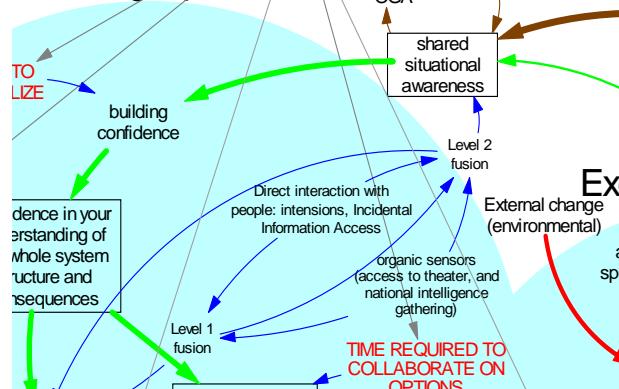


Industrial Age Hierarchy

Deconfliction

To Achieve Desired End State

Building Options



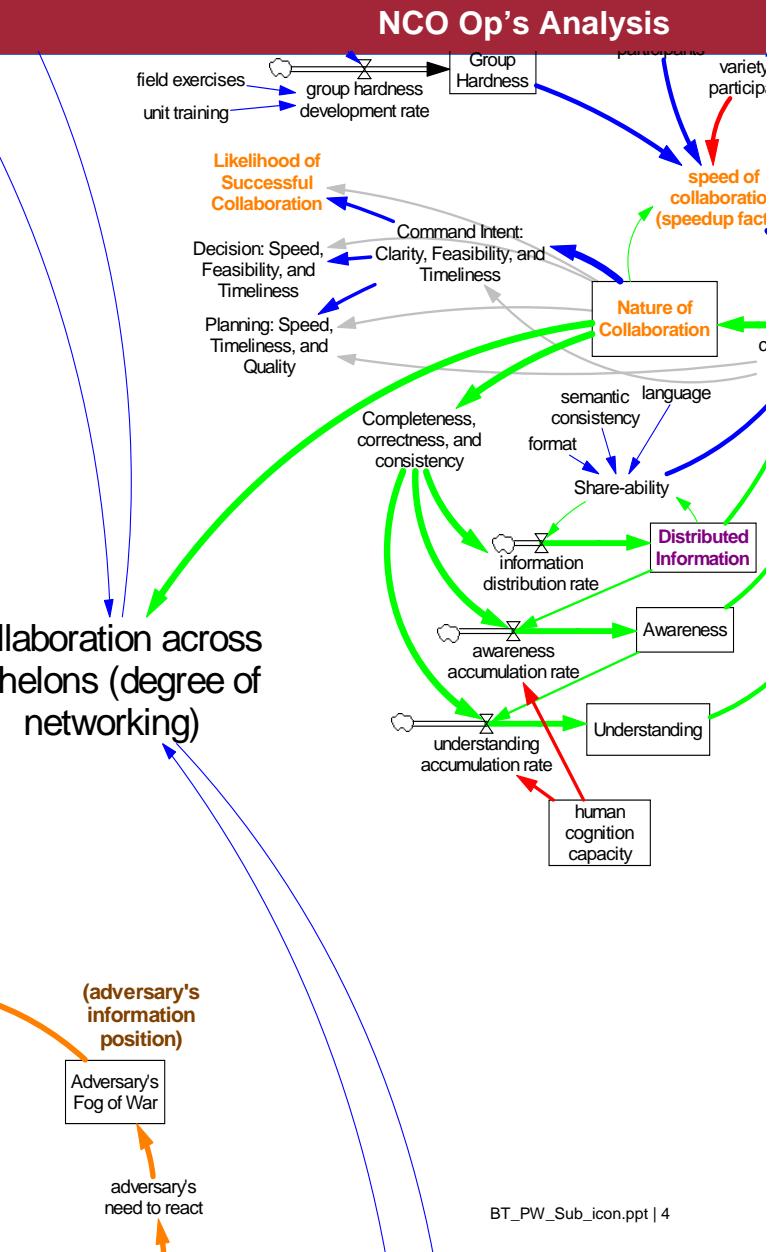
Exercising Options



Information Age Network

Synergy of Action

To Achieve Network of Results





Choosing a C2 Alternative

Boeing Technology | Phantom Works

NCO Op's Analysis

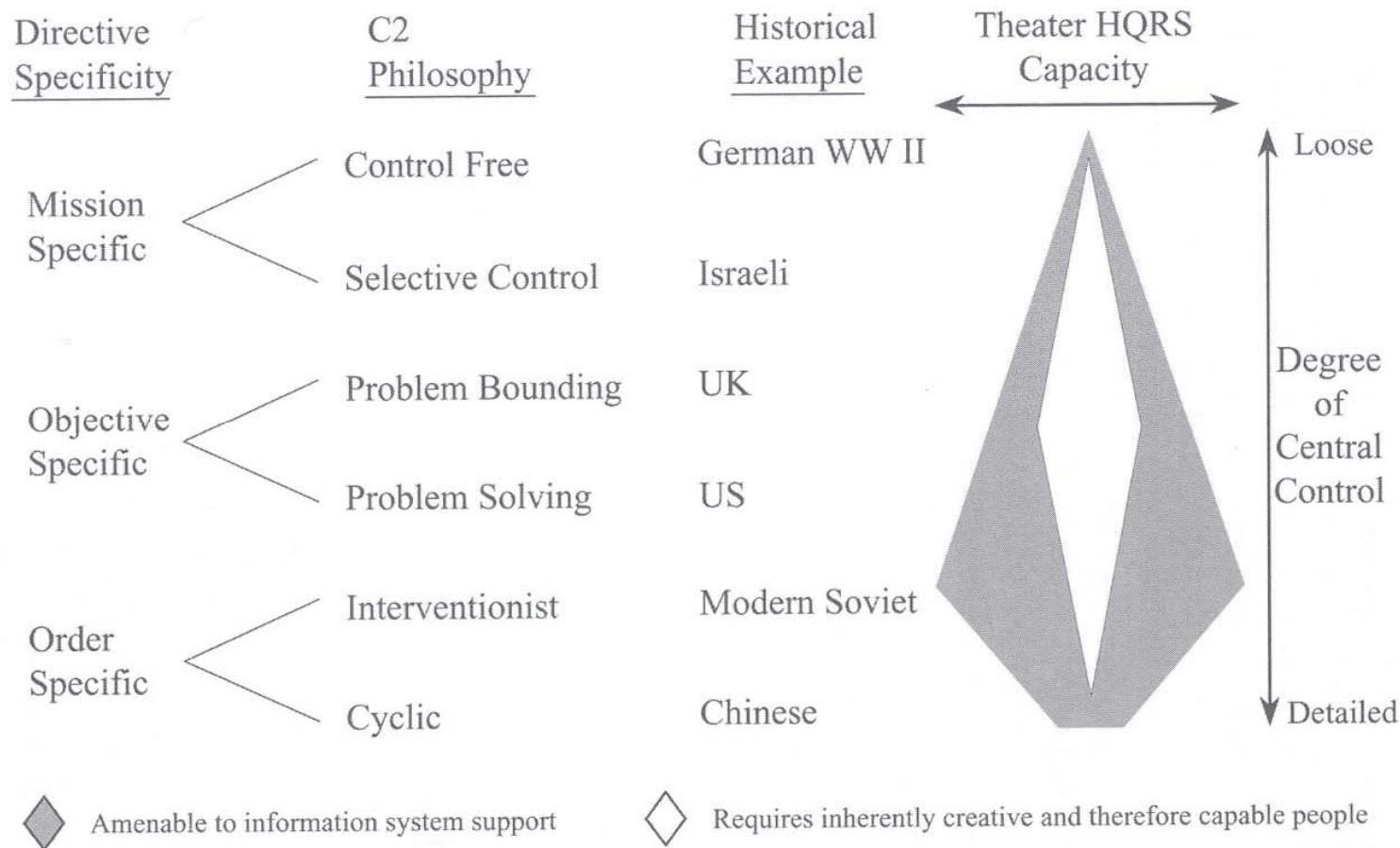


Figure 64. Historical Choices Among C2 System Philosophy



C2 Philosophy or Approach

Boeing Technology | Phantom Works

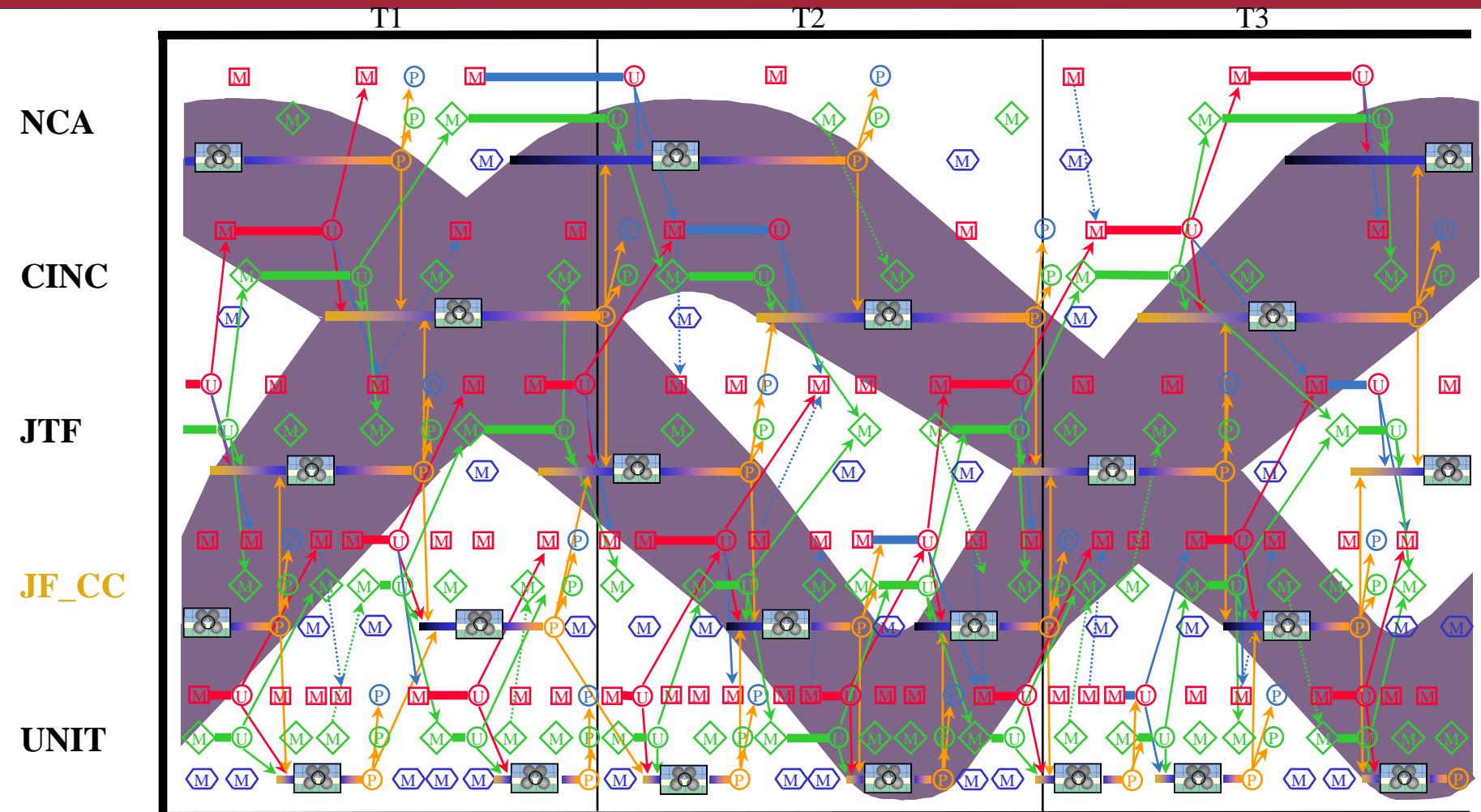
NCO Op's Analysis

- **Control Free** – initial intent, provide information and resources necessary for force elements to succeed
- **Selective Control** – establish initial conditions for success and then monitors for major threat/opportunity detection. (Assumes that subordinates respond promptly and effectively to new command intent.)
- **Problem Bounding** – missions offered to subordinates as problems (rich in contingencies and thin in detail)
- **Problem Solving** – specifying the objectives from operational headquarters (within constraints imposed by senior commanders)
- **Interventionist** – specific orders from theater level with changes at irregular intervals
- **Cyclic** – detailed orders from central command on a regular schedule

Joint Hierarchical and Cyclical Operational Activity Model

Boeing Technology | Phantom Works

NCO Op's Analysis



Legend

■ - Intelligence Monitoring	— - Intelligence Fusion	○ - Intelligence Understanding	○ - Intelligence Plan	— - C2 Fusion Process
◆ - Logistical Monitoring	— - Logistical Fusion	○ - Logistical Understanding	○ - Logistical Plan	— - C2 Planning Process
○ - C2 Monitoring → - Spot Reports			○ - C2 Plan
				○ - OODA Loop
				PW_Sub_icon.ppt 7



Information Delays Drive Oscillations

Boeing Technology | Phantom Works

NCO Op's Analysis

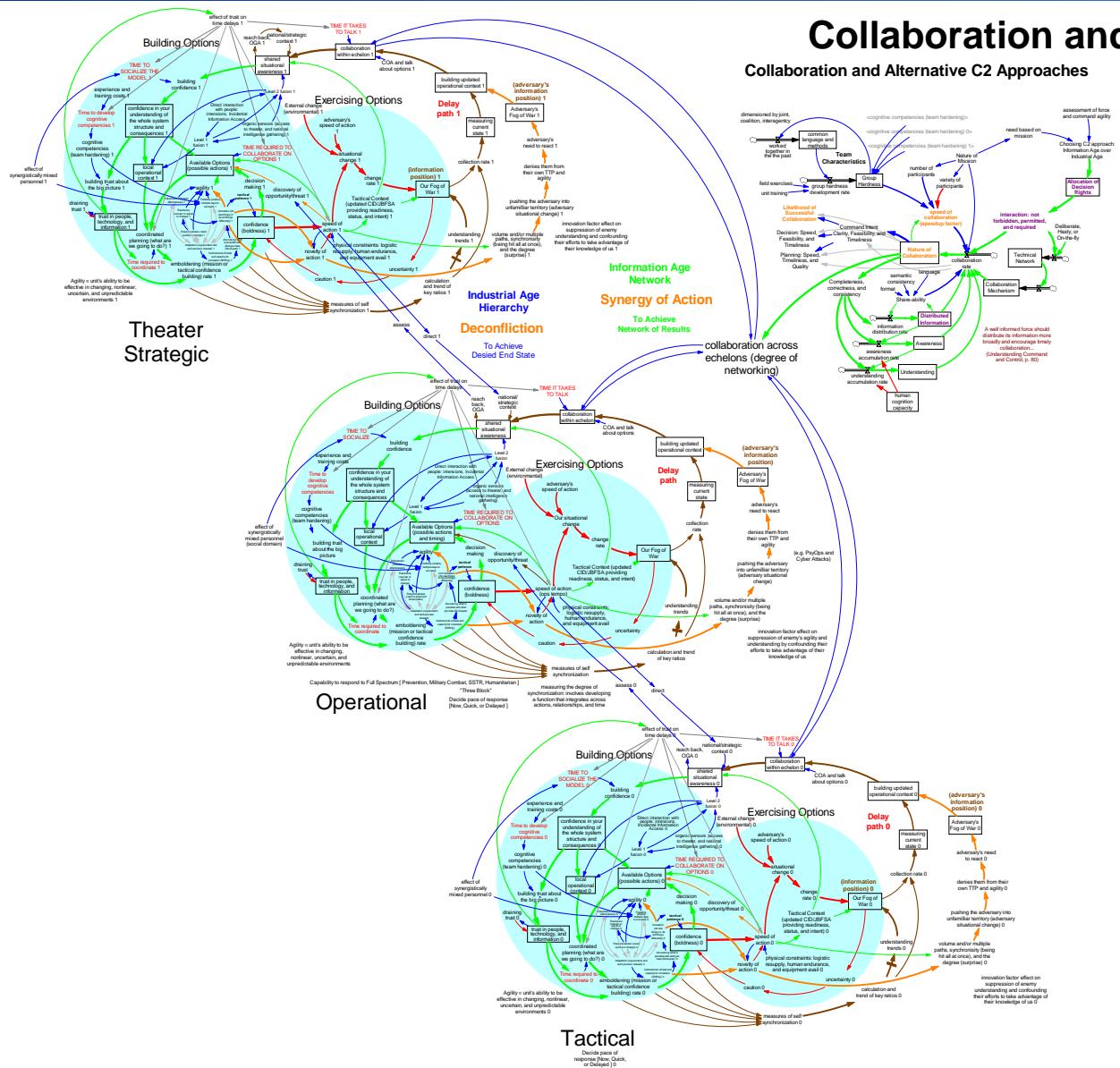
- **Goal**
 - Tell the same story outlined in the previous slides (taken from Understanding Information Age Warfare) using causal loop diagrams
- **Discovery**
 - The longer the information delays (collaboration, coordination, and communication), the longer period of oscillation
- **Insight**
 - Delays are central to the behavior of the system
- **Recommendation**
 - Come to an understanding of the sources and consequences of information delays both within and among echelons

Net-Enabled Command Capability is Coordination Across Echelons



Boeing Technology | Phantom Works

NCO Op's Analysis



Collaboration and Alternative C2 Approaches

Collaboration and Alternative C2 Approaches

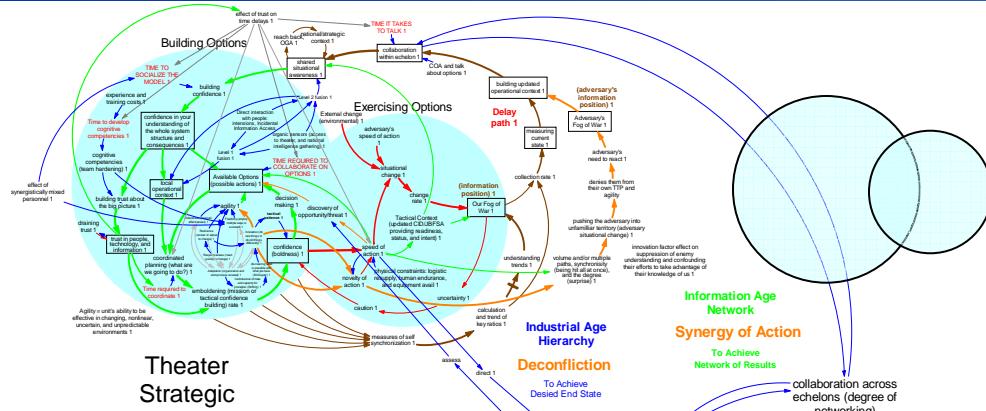
- **Control Free** – initial intent, provide information and resources necessary for force elements to succeed
- **Selective Control** – establish initial conditions for success and then monitors for major threat/opportunity detection. (Assumes that subordinates respond promptly and effectively to new command intent.)
- **Problem Bounding** – missions offered to subordinates as problems (rich in contingencies and thin in detail)
- **Problem Solving** – specifying the objectives from operational headquarters (within constraints imposed by senior commanders)
- **Interventionist** – specific orders from theater level with changes at irregular intervals
- **Cyclic** – detailed orders from central command on a regular schedule

Exploring the importance of Agility

Boeing Technology | Phantom Works



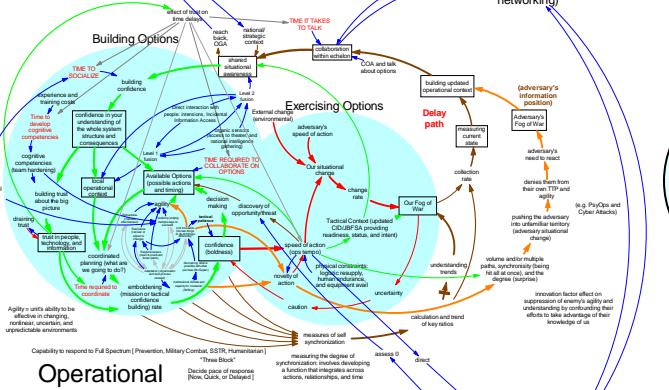
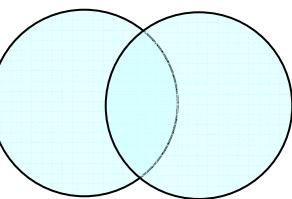
NCO Op's Analysis



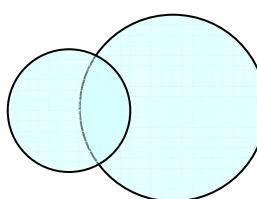
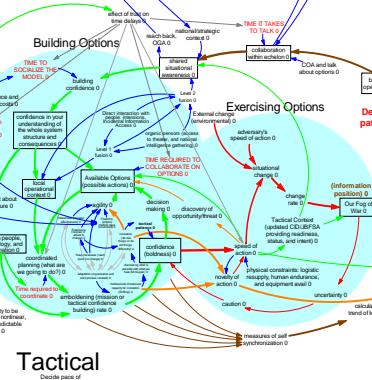
Observation: Each layer has a unique balance between building and exercising options

Discovery: This dictates differences in time delays to perform a function

Insight: To maintain momentum, the regeneration of options becomes the constraint



Insight: The agility of the operating units requires an agility within the command structure so that Ops Tempo can be matched with Battle Rhythm

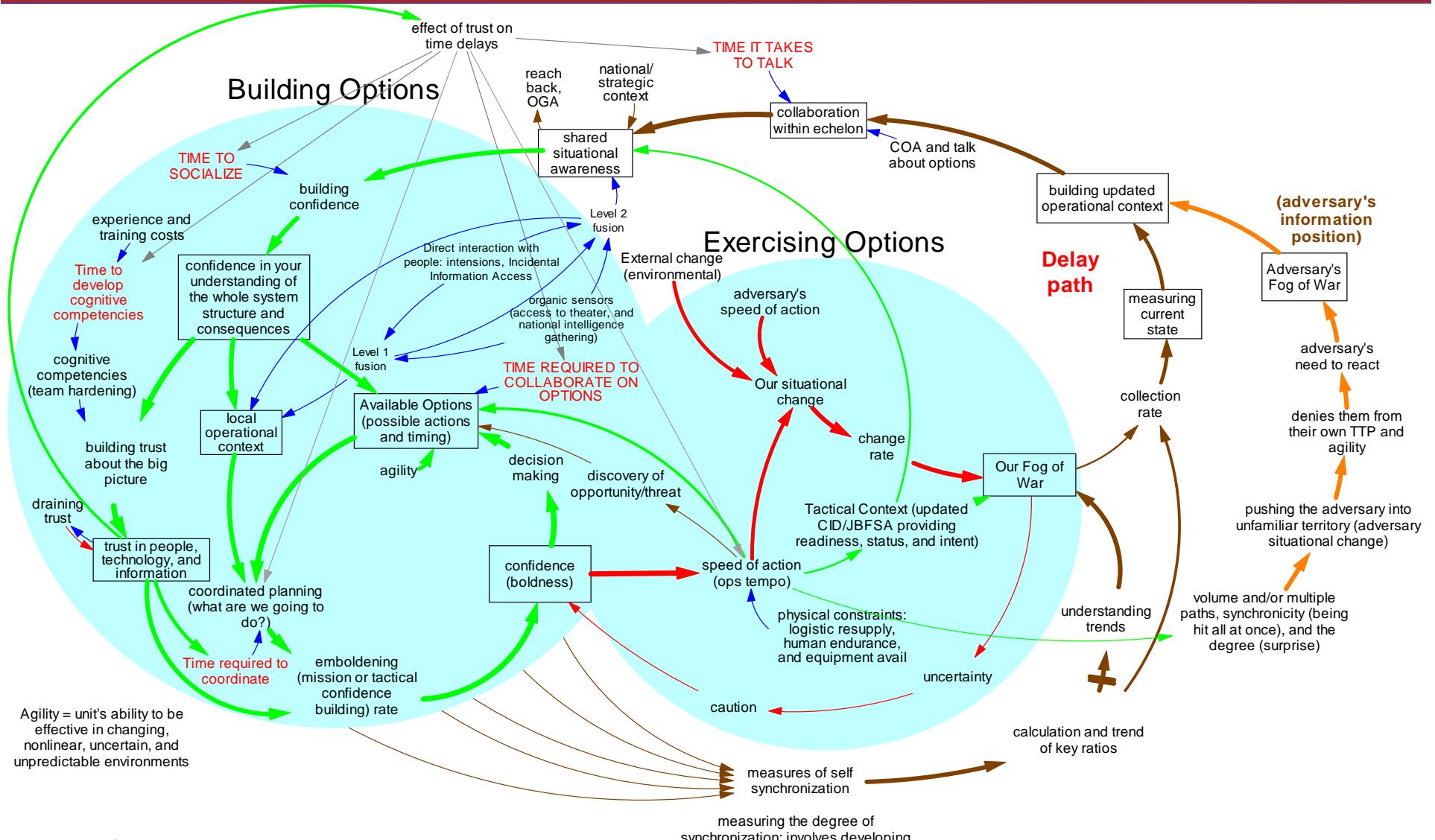




Agility in Context

Boeing Technology | Phantom Works

NCO Op's Analysis



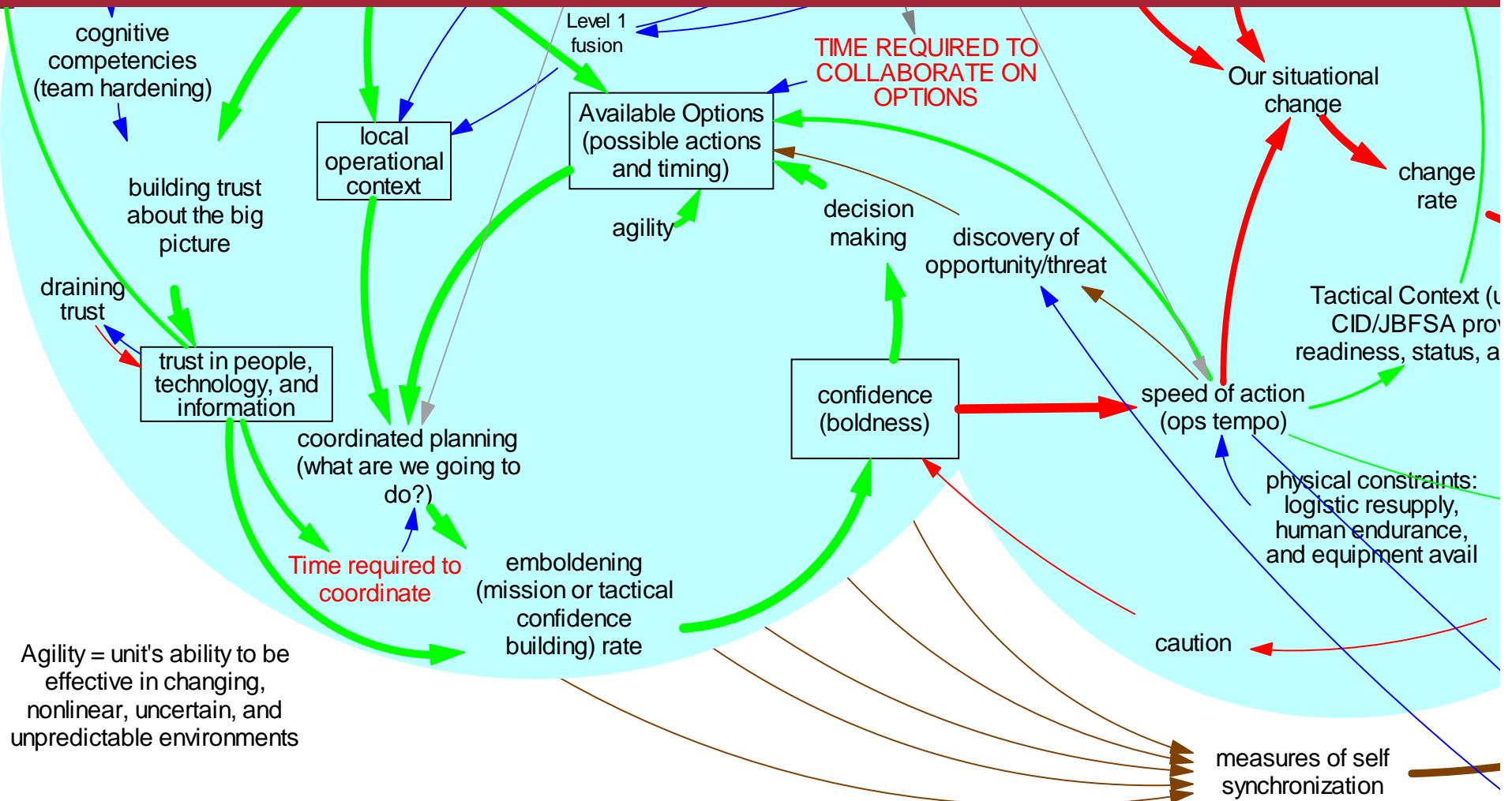
Operational



Agility in Focus

Boeing Technology | Phantom Works

NCO Op's Analysis



Operational

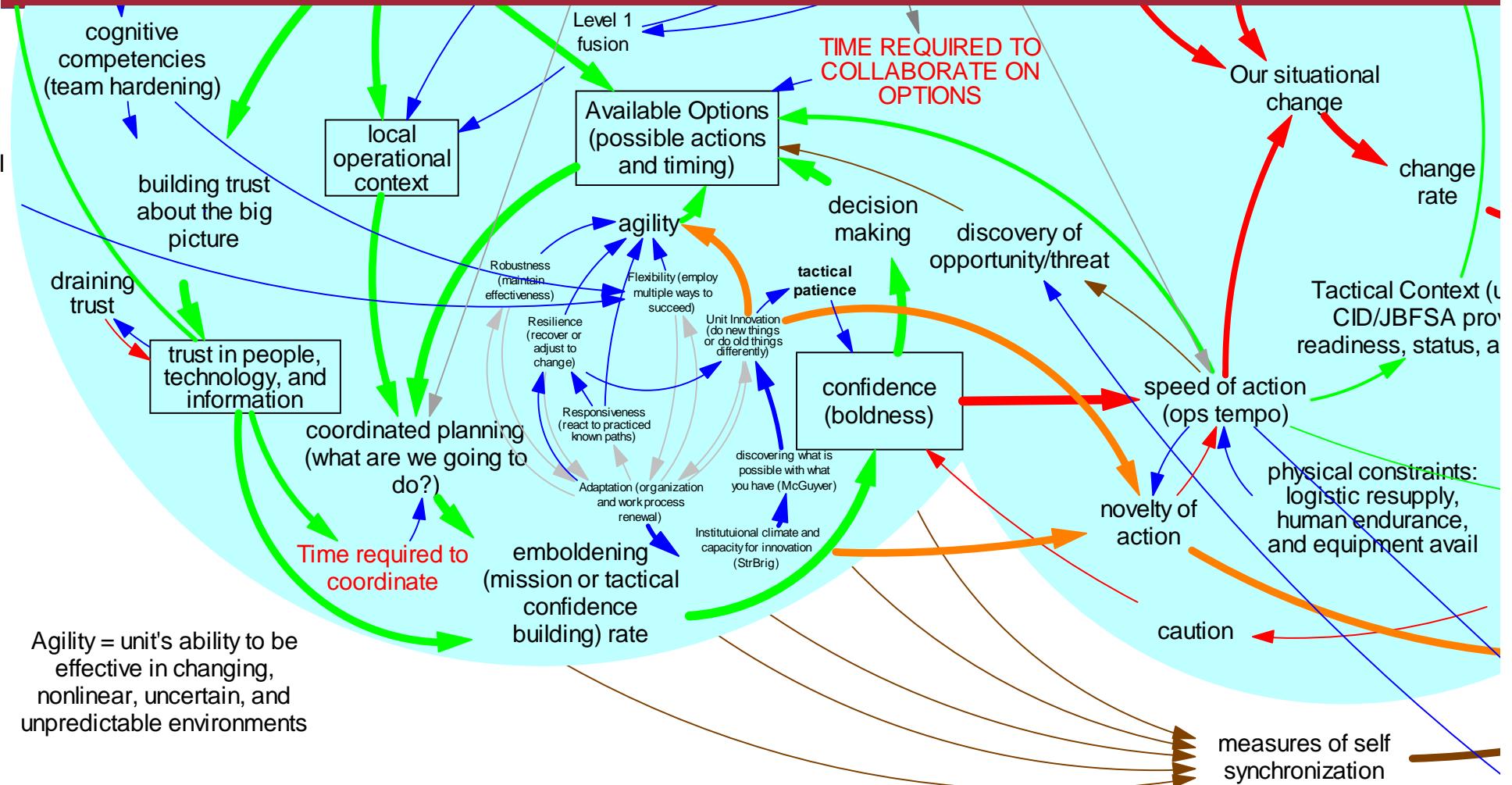
measuring the degree of synchronization: involves developing a function that integrates across actions, relationships, and time



Agility in Focus

Boeing Technology | Phantom Works

NCO Op's Analysis



Capability to respond to Full Spectrum [Prevention, Military Combat, SSTR, Humanitarian]

"Three Block"

Decide pace of response
[Now, Quick, or Delayed]

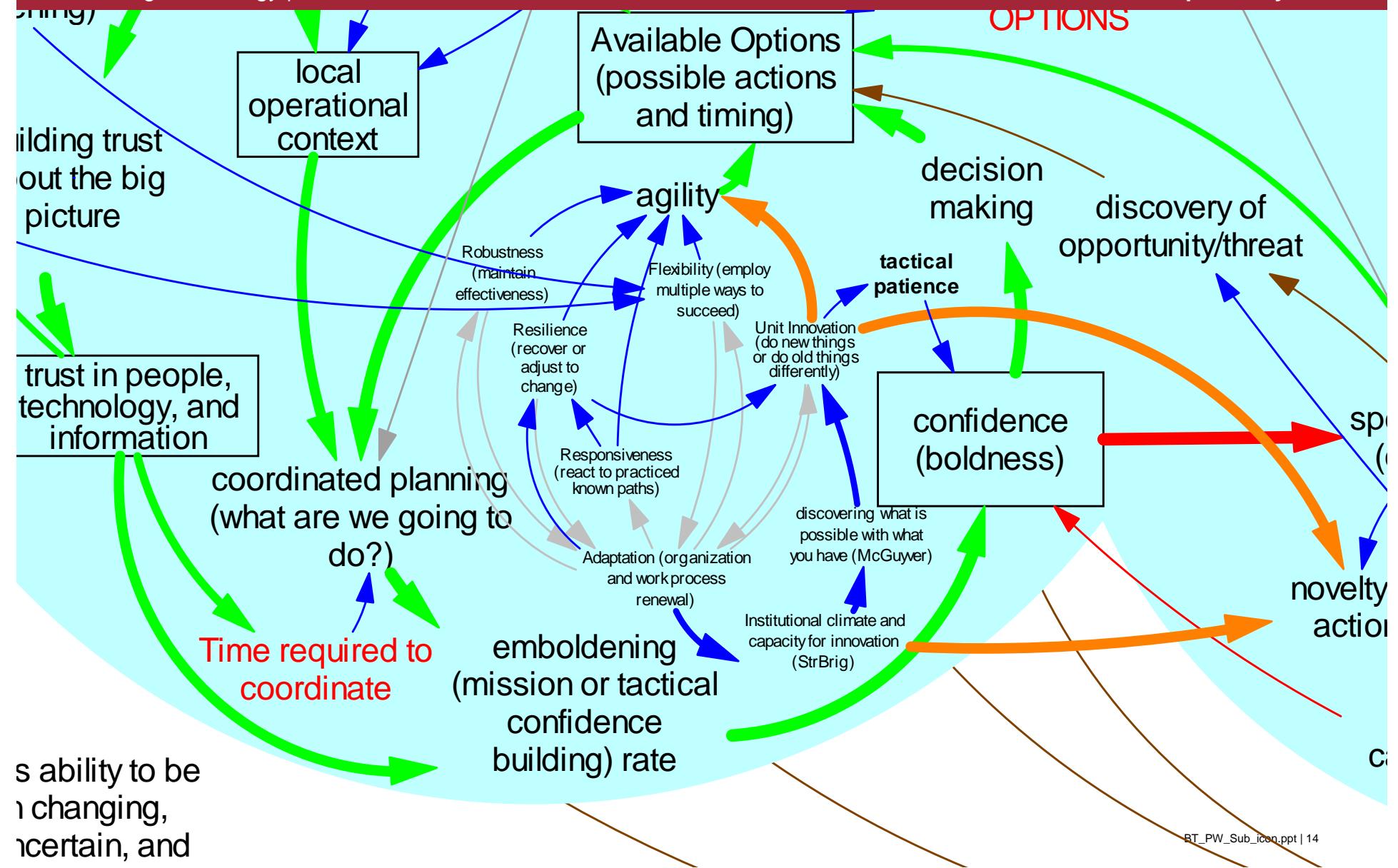
Operational



Agility: Characteristics and Influences

Boeing Technology | Phantom Works

NCO Op's Analysis

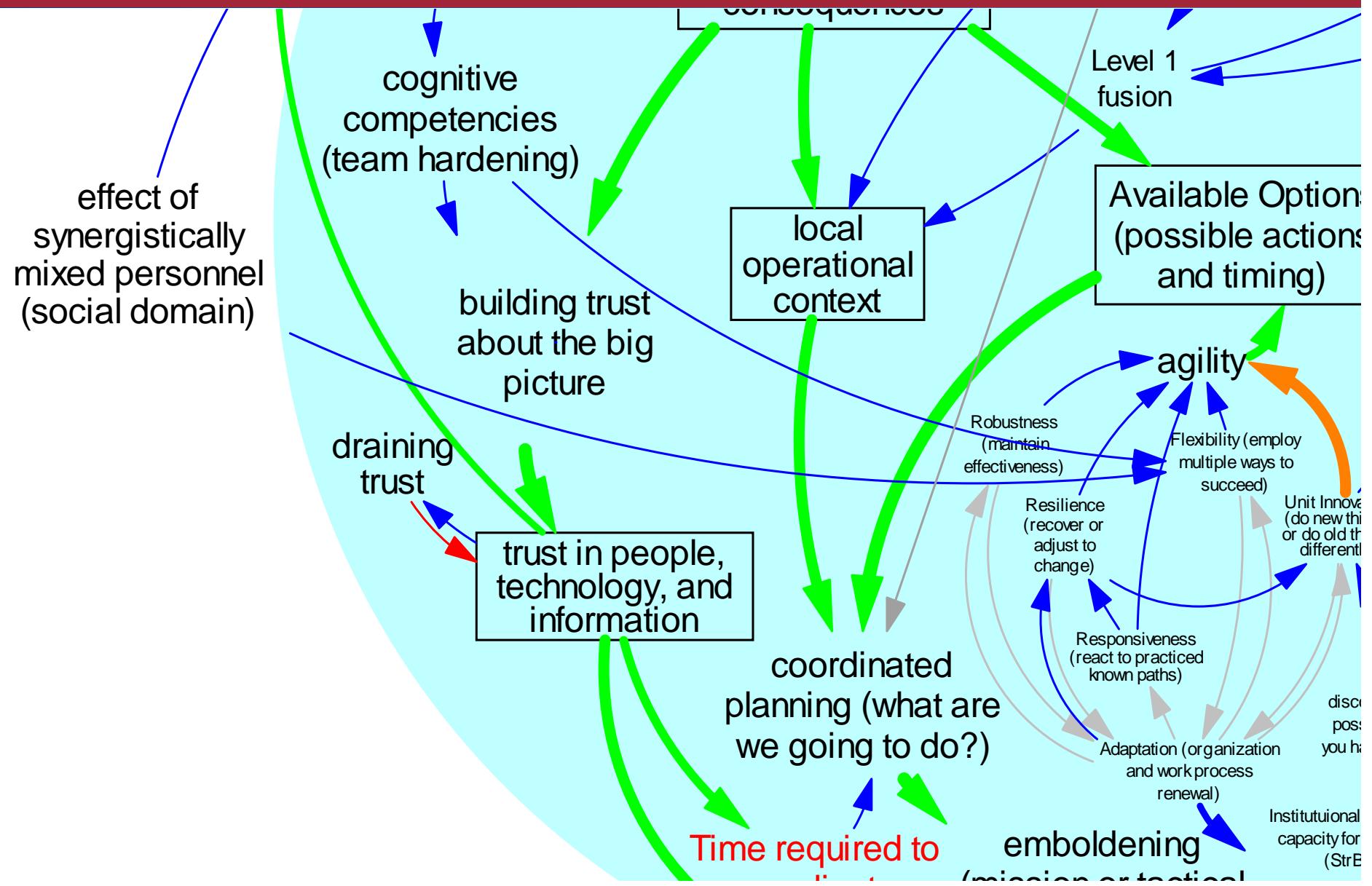




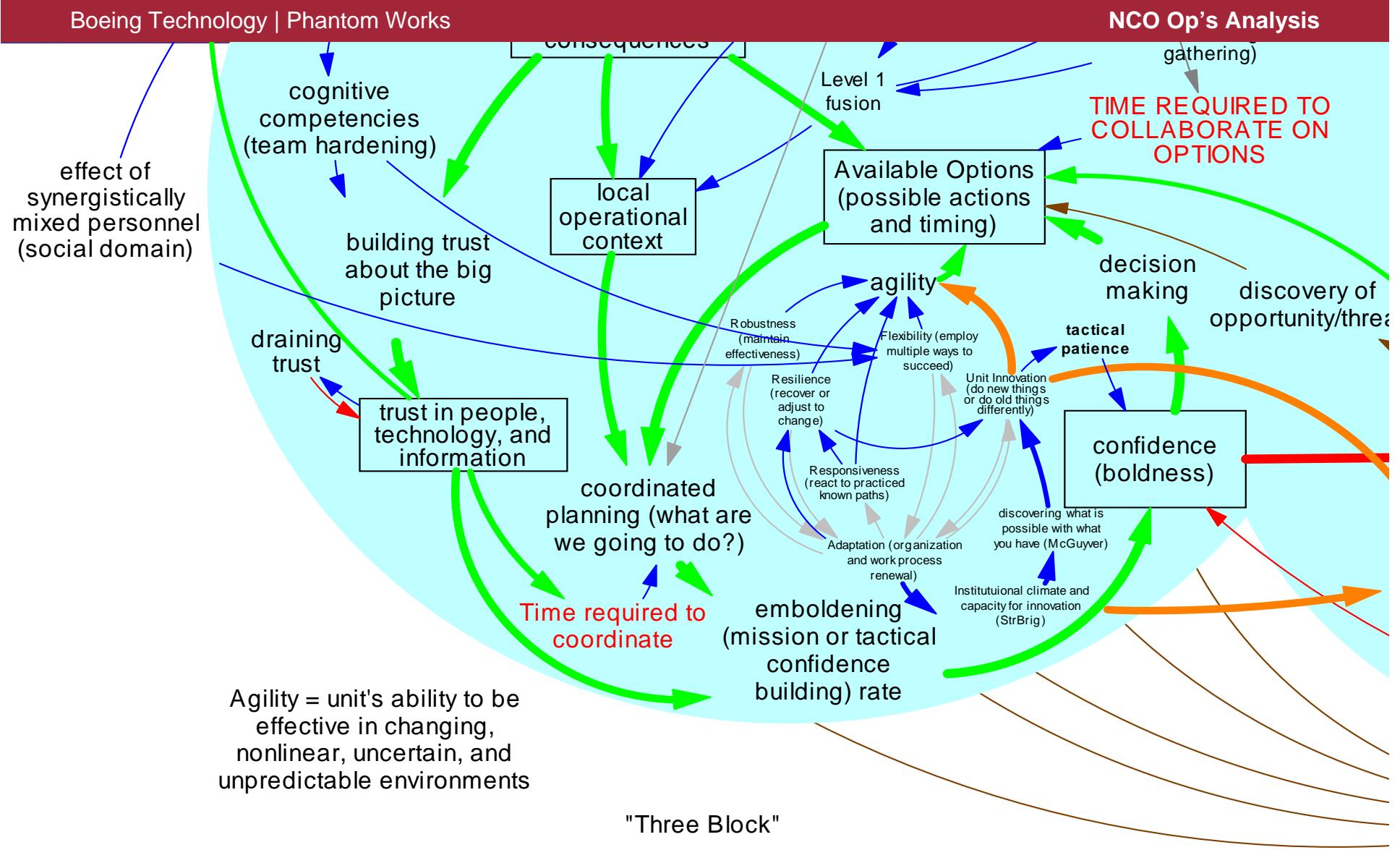
Social Diversity and Team Hardening

Boeing Technology | Phantom Works

NCO Op's Analysis



Social Diversity and Innovation Fuel Agility



Agility = unit's ability to be effective in changing, nonlinear, uncertain, and unpredictable environments

"Three Block"

Capability to respond to Full Spectrum [Prevention, Military Combat, SSTR, Humanitarian]
Decide pace of response [Now, Quick, or Delayed]

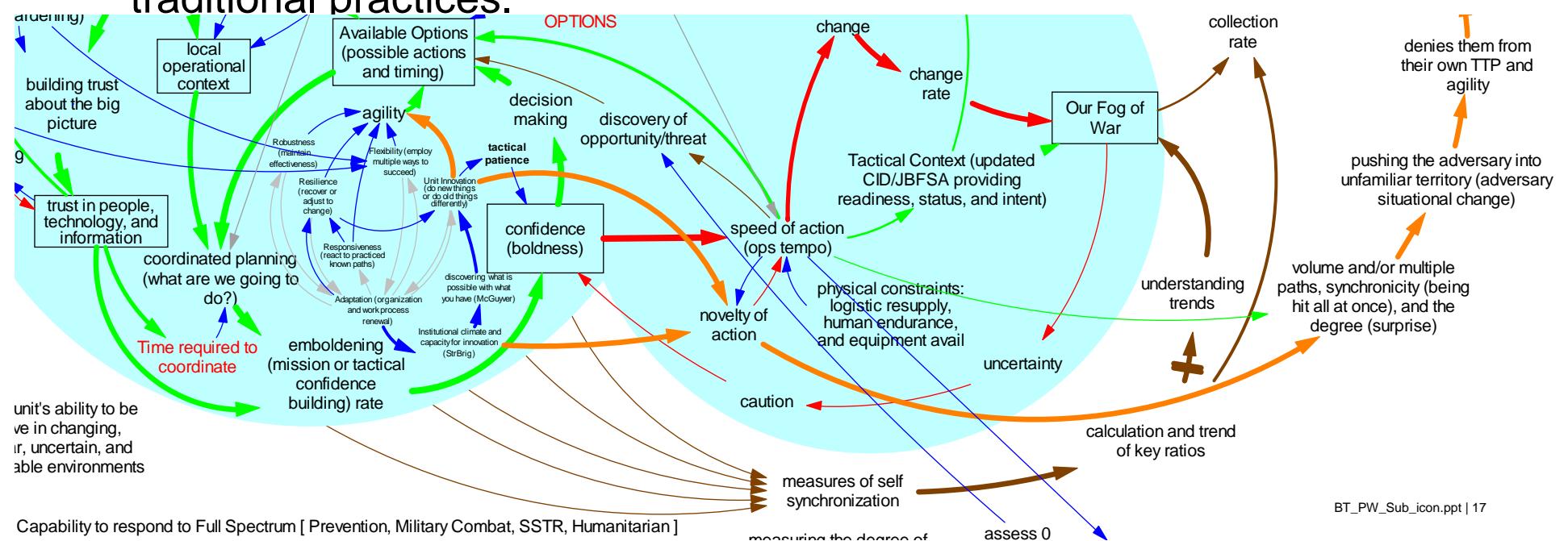


Global Impact of Unit Innovation

Boeing Technology | Phantom Works

NCO Op's Analysis

- Observation: Agility is an essential for building, maintaining, and acting on options. Robustness, Resilience, Responsiveness, and Flexibility synergistically work toward increased agility. Adaptation and Innovation operate at a different time scale from the others.
- Discovery: Adaptation and Innovation unlike the others influence the novelty of action, which puts them into a class apart, and at odds with traditional practices.

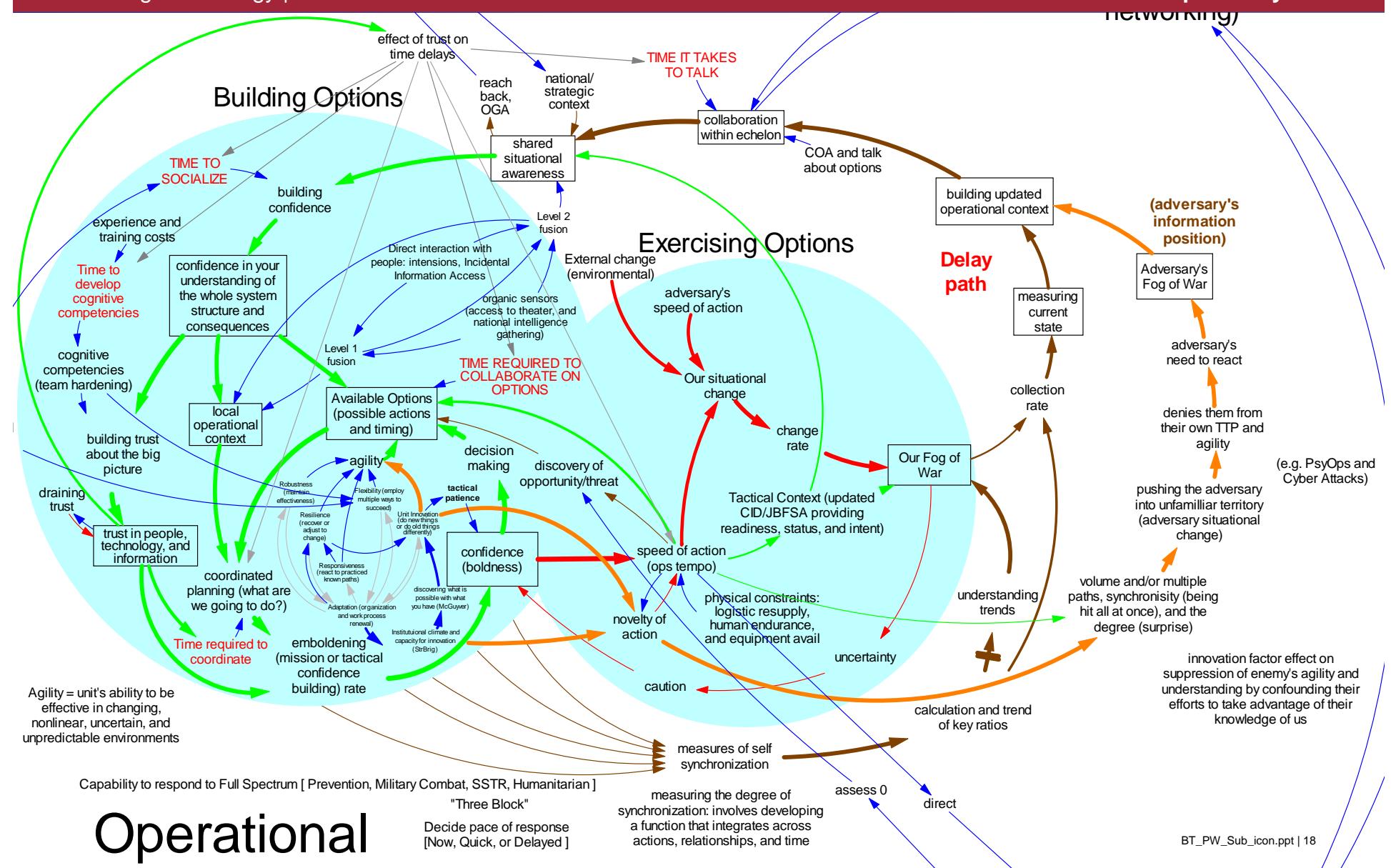


Discovering Connectivity with Novelty of Action and Impact to Adversary



Boeing Technology | Phantom Works

NCO Op's Analysis





Self-Coordination

Boeing Technology | Phantom Works

NCO Op's Analysis

Some current military parlance employs the term self-coordination in place of self-synchronization. The DoD Transformational Planning Guidance issued in April 2003 defines self-coordination as an effort to “increase freedom of low level forces to operate near-autonomously and re-task themselves through exploitation of shared awareness and commander’s intent.” This definition is consistent with our concept of self-synchronization.

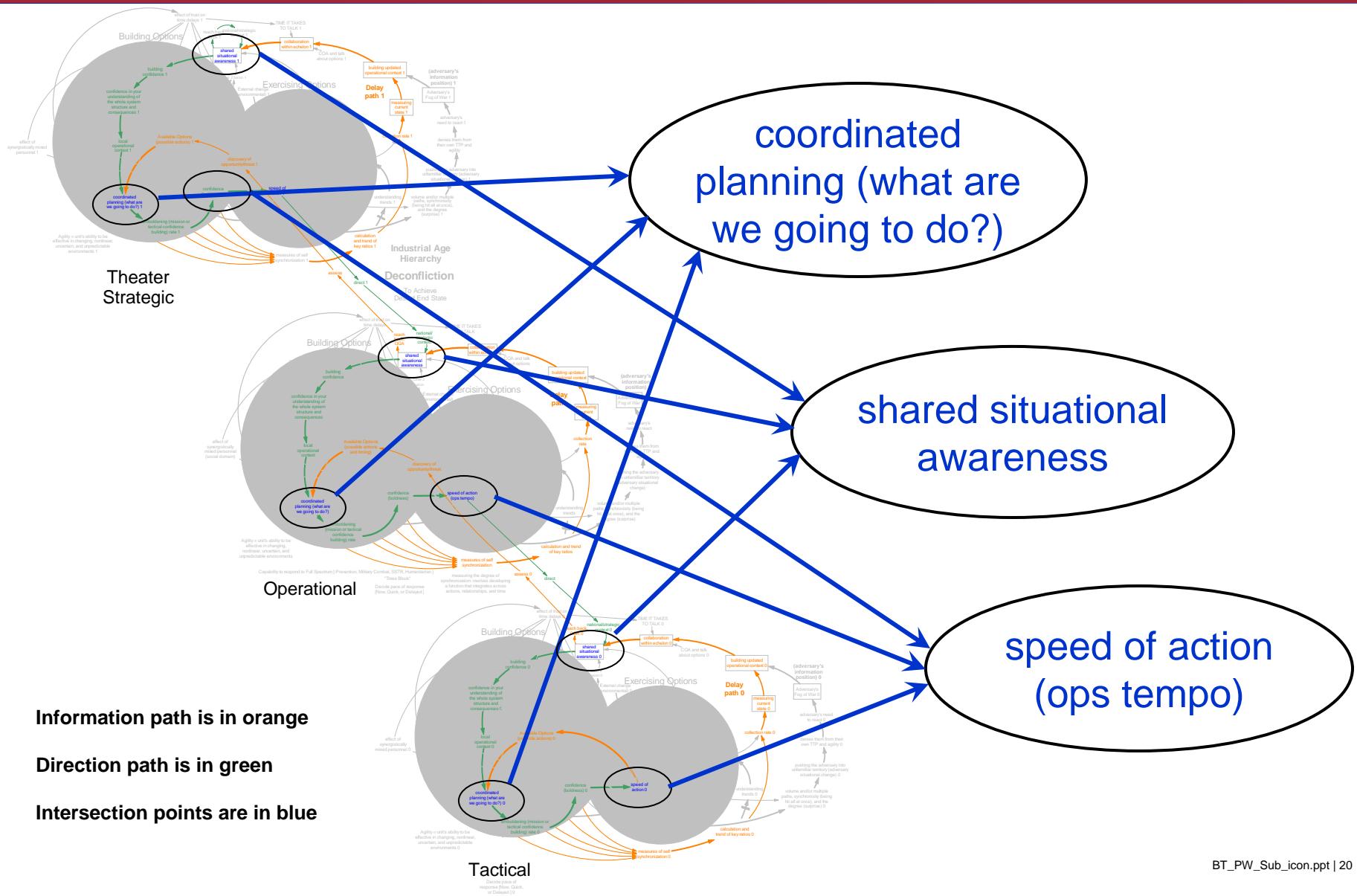
Rumsfeld, Donald H. Transformational Planning Guidance. Department of Defense. April 2003.

Confluence of Information and Direction



Boeing Technology | Phantom Works

NCO Op's Analysis

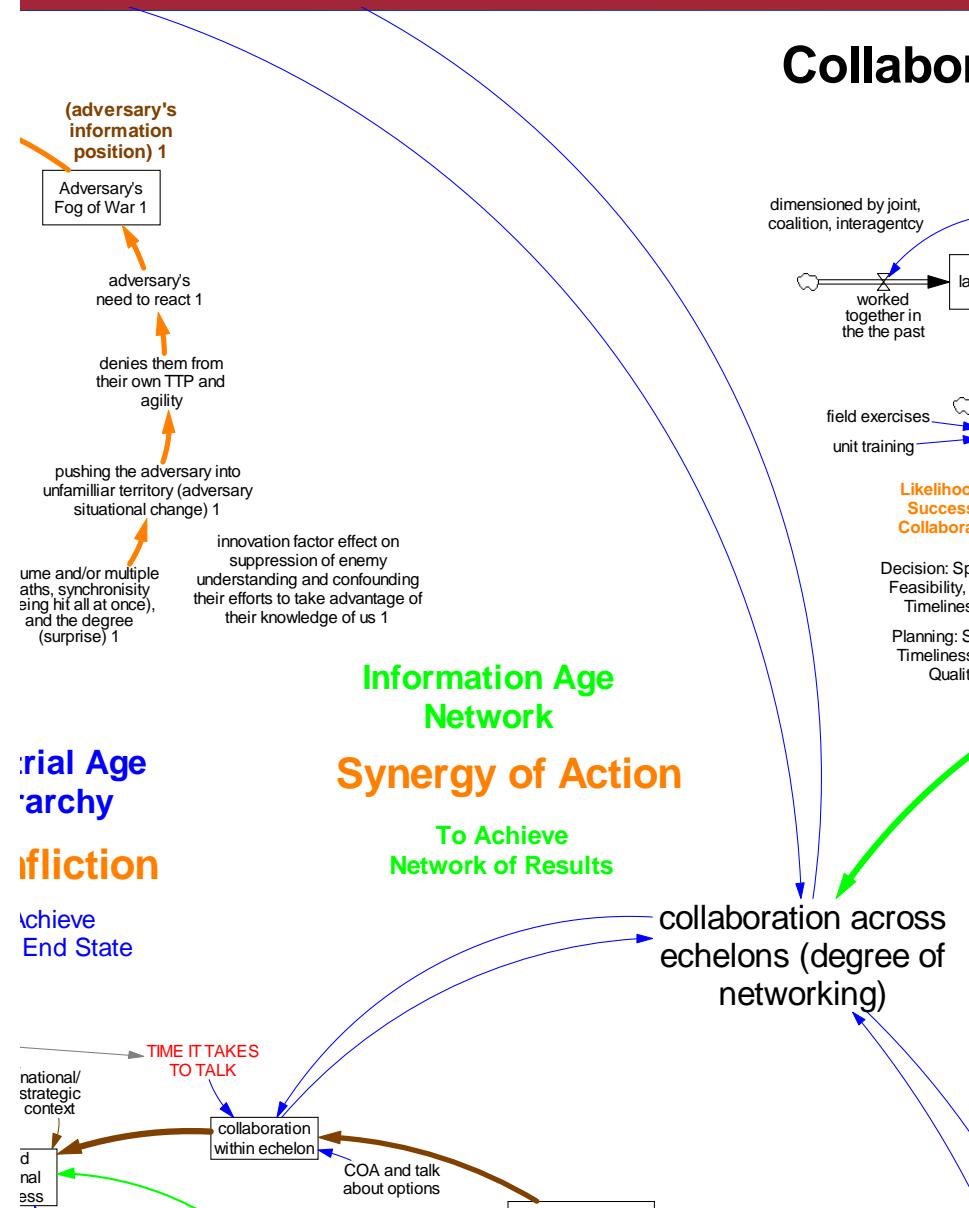




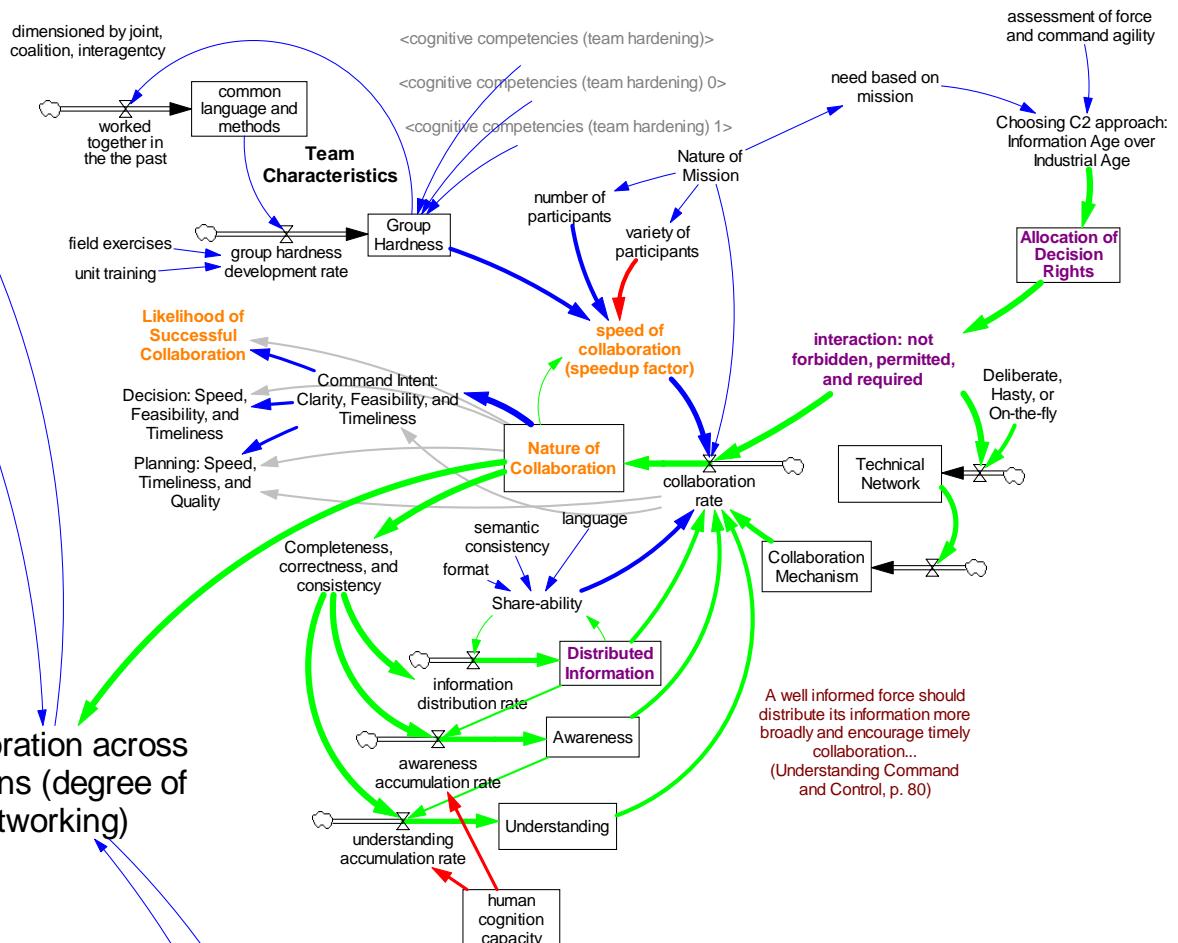
Collaboration and Alternative C2

Boeing Technology | Phantom Works

NCO Op's Analysis



Collaboration and Alternative C2 Approaches

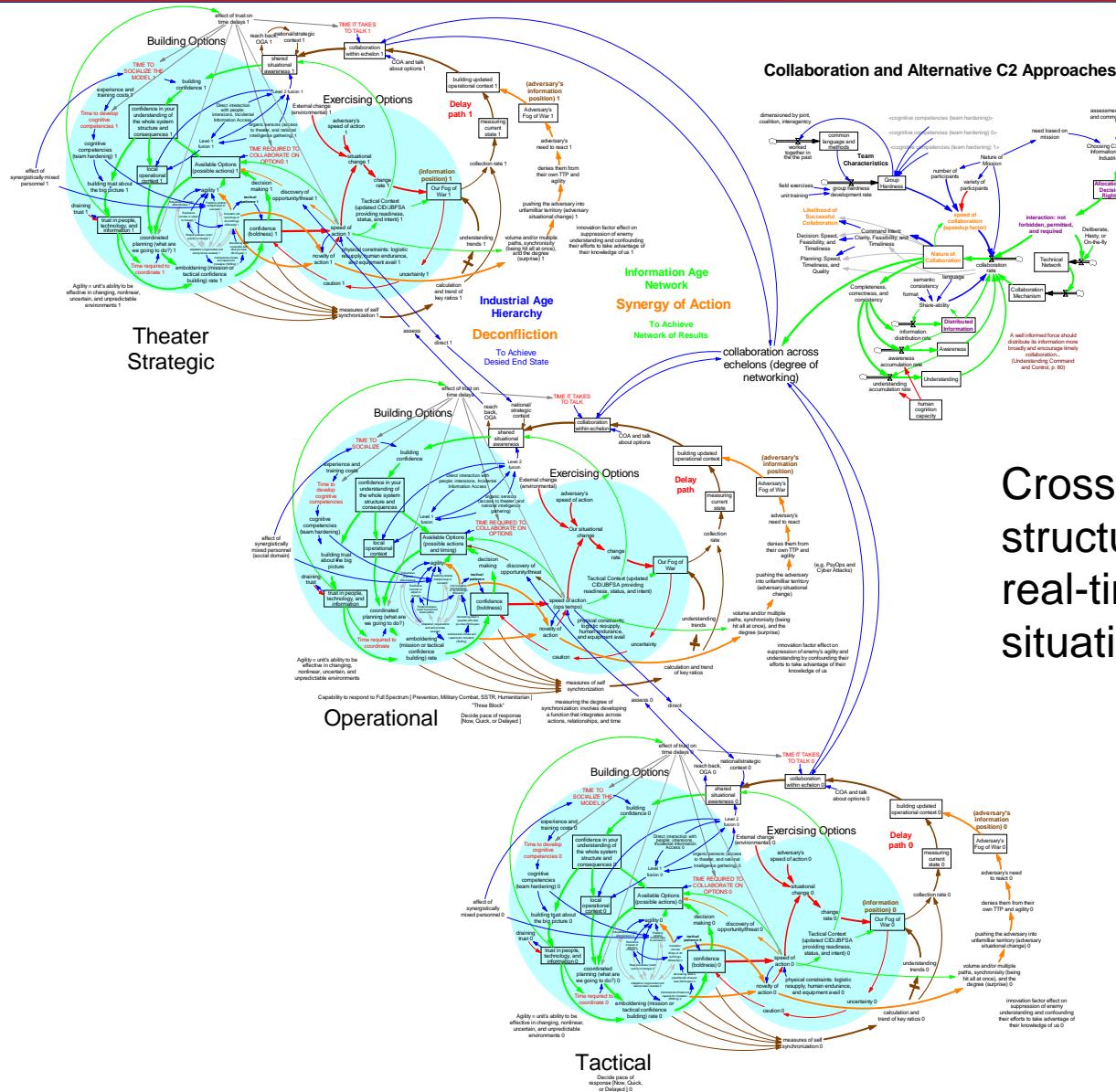


Net-Enabled Command Capability is Coordination Across Echelons



Boeing Technology | Phantom Works

NCO Op's Analysis



Cross echelon network structure results in near real-time shared situational awareness

Information age
collaboration creates
options for new and more
effective C2 Approaches

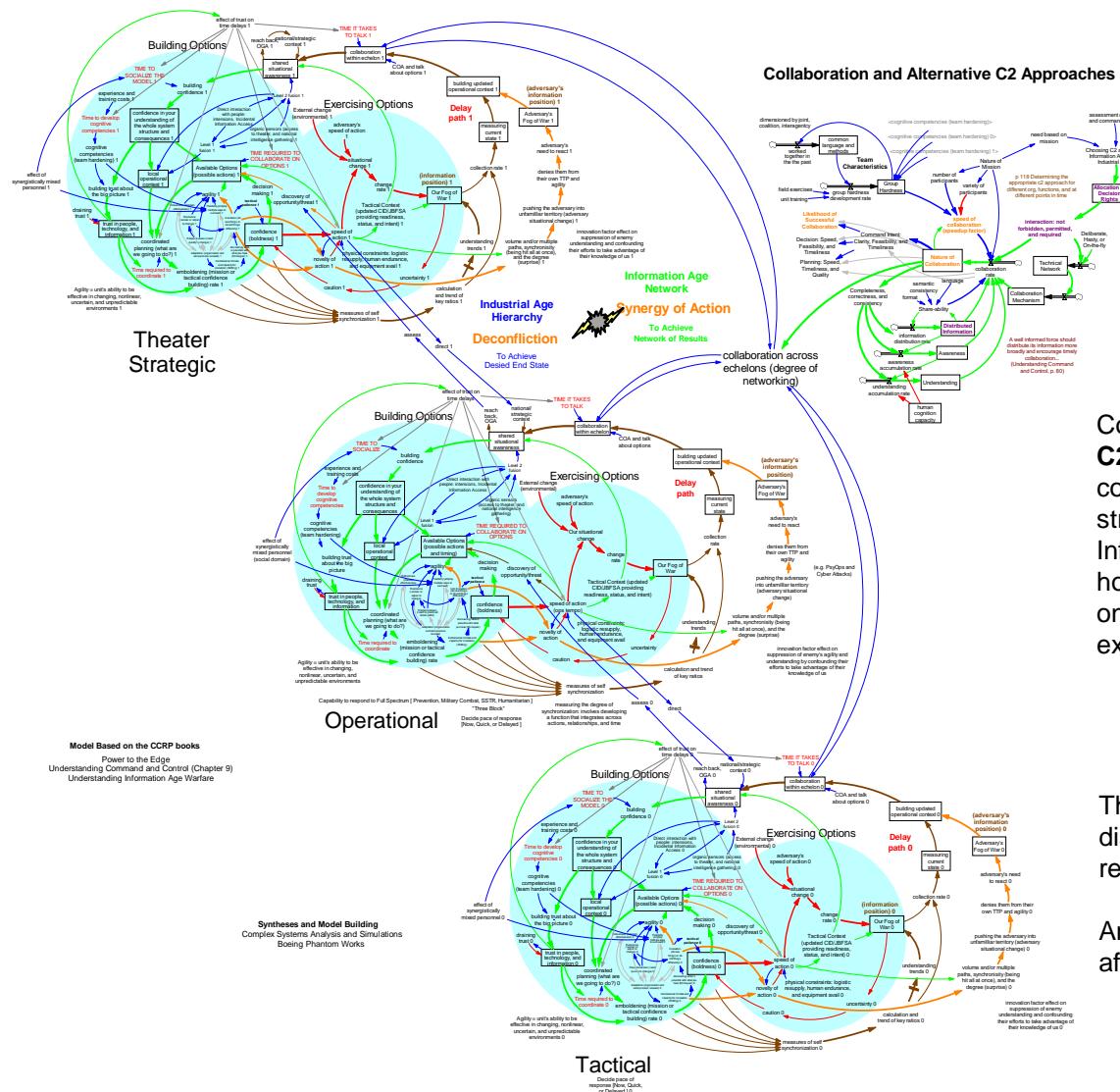
Net-Enabled Command Capability is Coordination Across Echelons



Boeing Technology | Phantom Works

NCO Op's Analysis

Choosing a C2 Approach



Collaboration and C2

Collaboration...is one of the cornerstones of any **C2 Approach** and the extent and role of collaboration is one of the factors that most strongly differentiates Industrial Age from Information Age approaches. Research into how to best organize and use collaboration is one of the areas where future research and experimentation should focus. (pp. 185,186)



Exploring the knowledge landscape

The three purposes for experiments are discovery, hypothesis testing (preliminary and refined), and then demonstration. (pg. 73)



Analysis needs to take place before, during, and after the conduct of each experiment. (pg. 76)



Collaboration Differentiates C2

Boeing Technology | Phantom Works

NCO Op's Analysis

Collaboration and C2

Collaboration...is one of the cornerstones of any **C2 Approach** and the extent and role of collaboration is one of the factors that most strongly differentiates Industrial Age from Information Age approaches. Research into how to best organize and use collaboration is one of the areas where future research and experimentation should focus. (pp. 185,186)



Campaigns of Experimentation – Value of System Dynamics



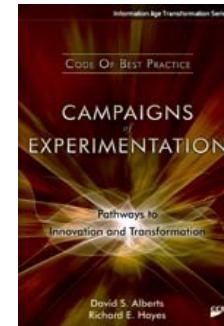
Boeing Technology | Phantom Works

NCO Op's Analysis

Exploring the knowledge landscape

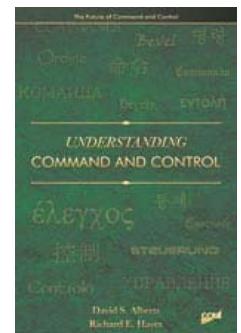
The three purposes for experiments are discovery, hypothesis testing (preliminary and refined), and then demonstration. (pg. 73)

Analysis needs to take place before, during, and after the conduct of each experiment. (pg. 76)



Capturing the Knowledge

These networks of influence could be used as the basis for the experimentation and observation necessary to construct such influence models and capture them in formal tools such as System Dynamics ... (pg 179)





Authors' Contact Email Addresses

Boeing Technology | Phantom Works

NCO Op's Analysis

Bob L. Wiebe

Robert.l.wiebe@boeing.com

Dan S. Compton

Dan.s.compton@boeing.com

David Garvey

David.r.garvey@boeing.com



Boeing Technology
Phantom Works

Phantom

Backup Slides

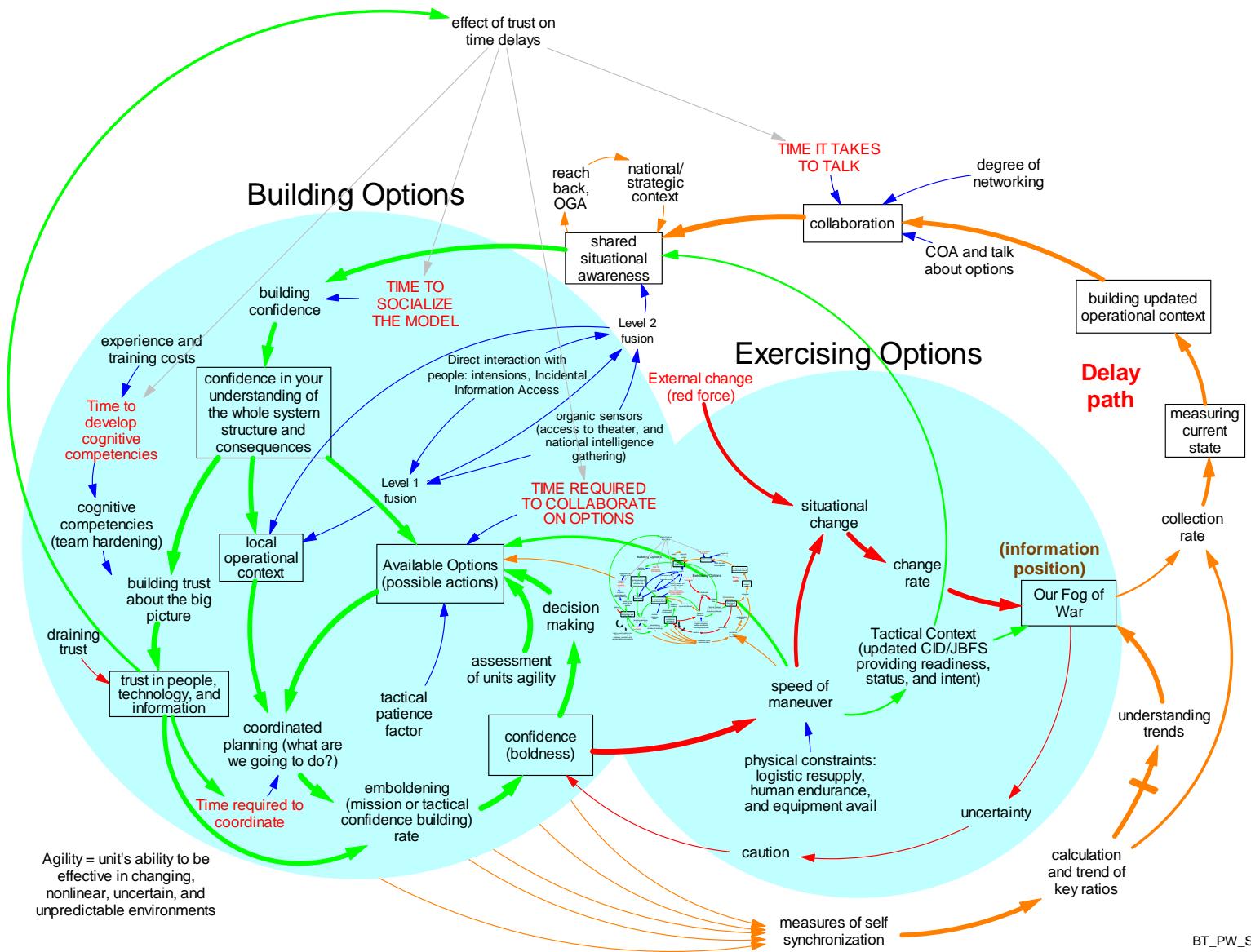


Loop diagram with fractal definition



Boeing Technology | Phantom Works

NCO Op's Analysis

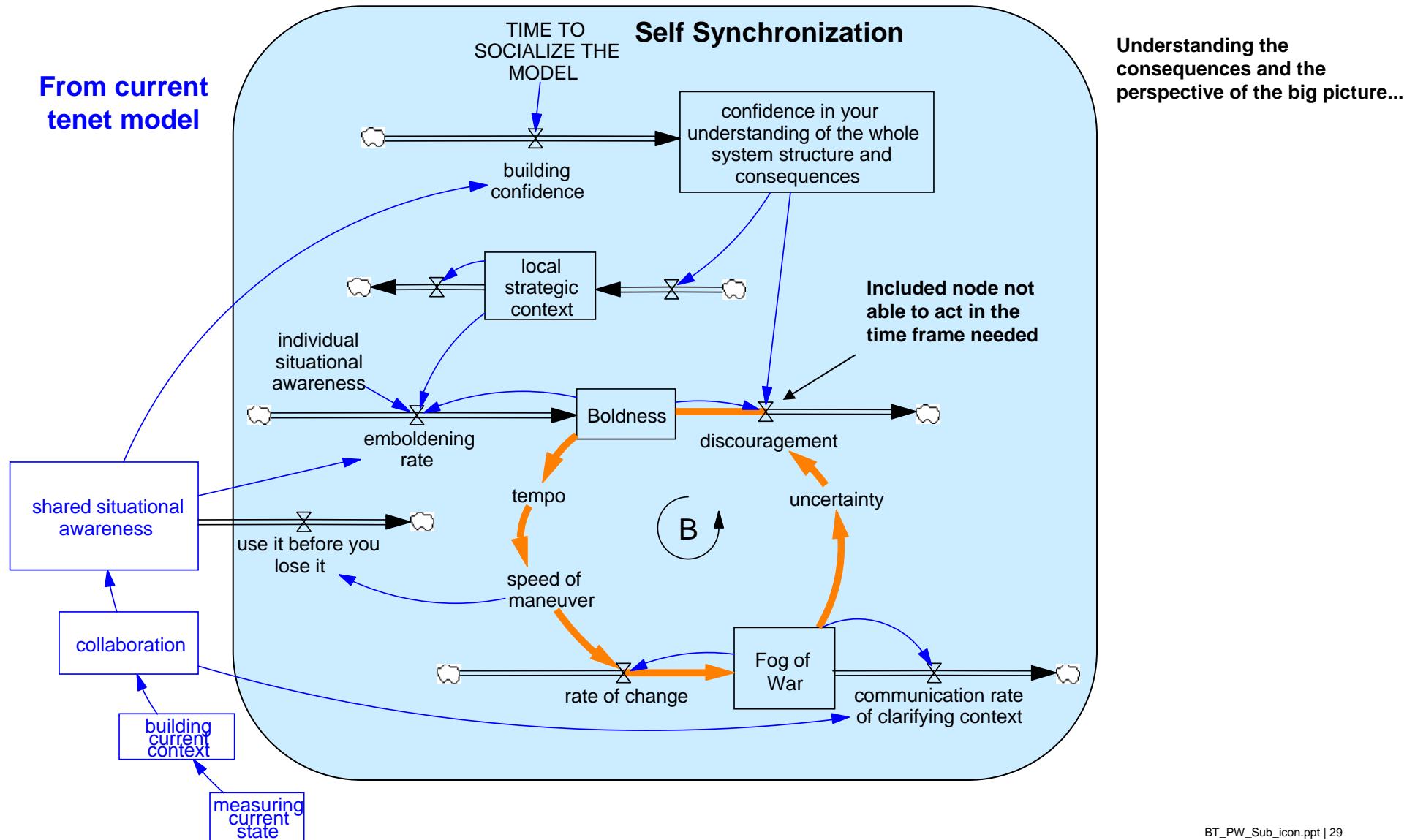




Self-Synchronization Tenet

Boeing Technology | Phantom Works

NCO Op's Analysis

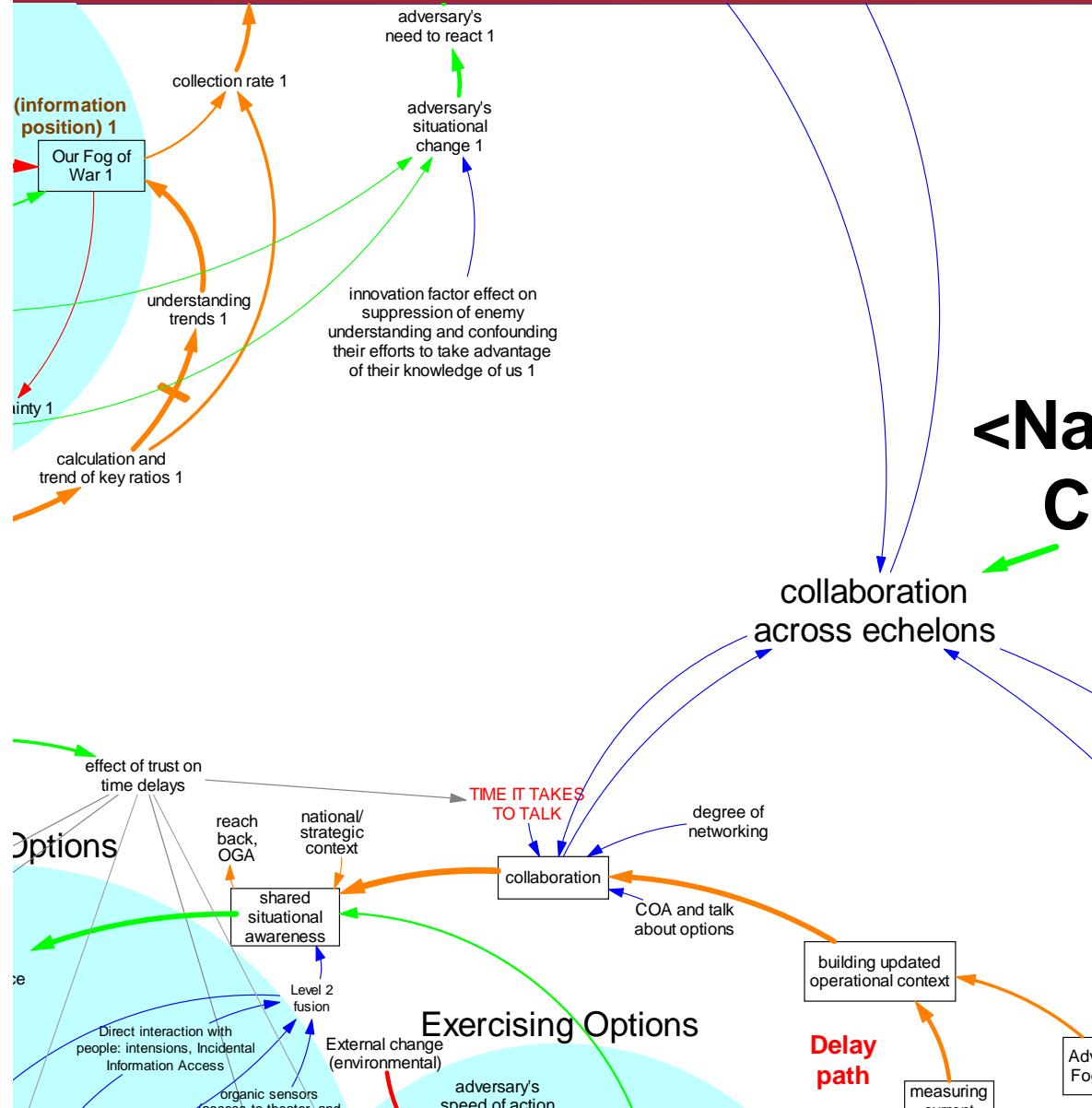


Collaboration Drives Alternative C2 Approaches



Boeing Technology | Phantom Works

NCO Op's Analysis



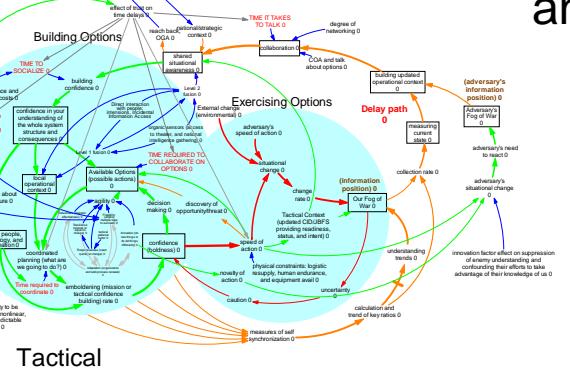
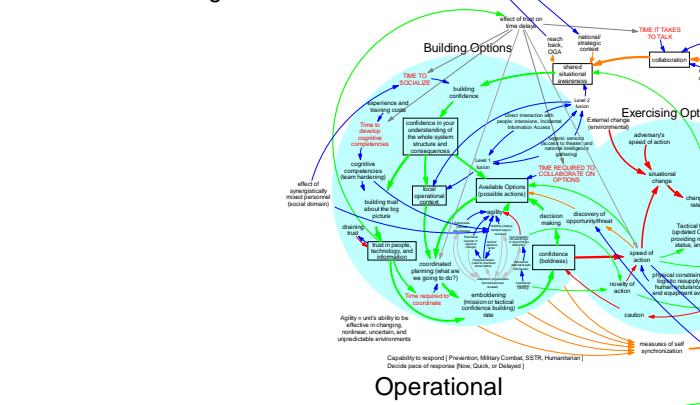
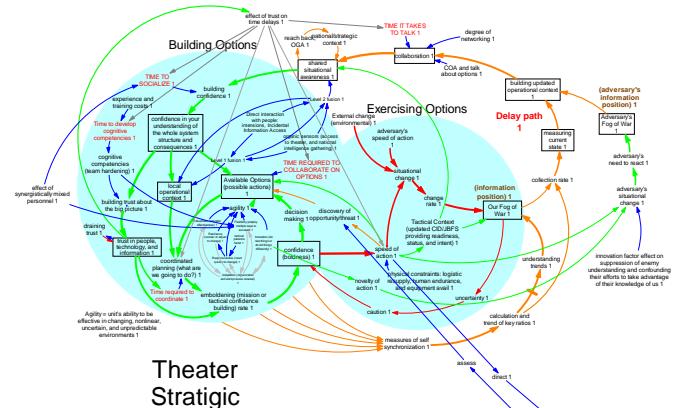
<Nature (quality) of Collaboration>

Discovering Connectivity Among Echelons

Boeing Technology | Phantom Works



NCO Op's Analysis



Observation: Consistent stories can be told with defined relationships within and among echelons

Discovery: The same pattern of relationships exist at each echelon layer

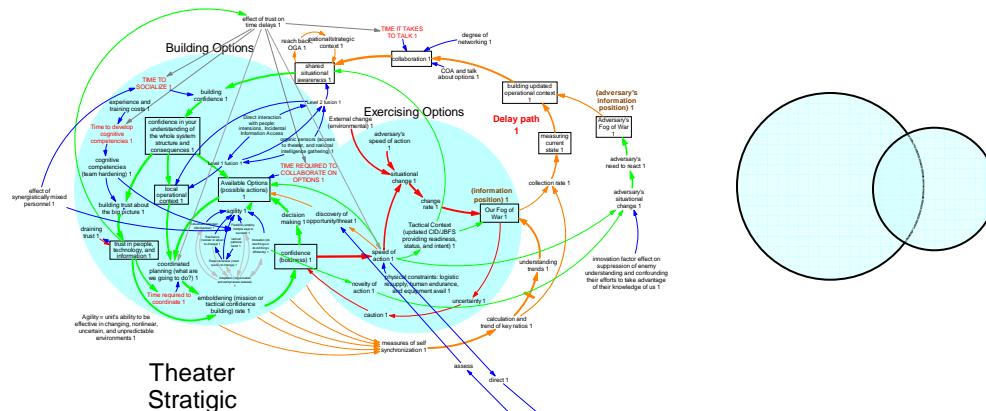
Insight: Each echelon is analogous to the others with broadening or narrowing of scope, focus (mission definition and roles), and time horizon

Discovering Connectivity Among Echelons

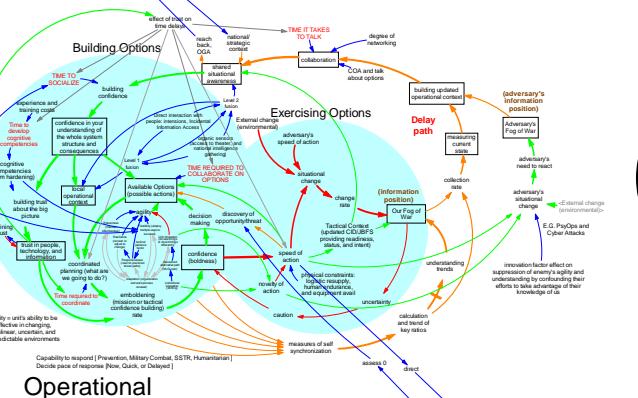
Boeing Technology | Phantom Works



NCO Op's Analysis

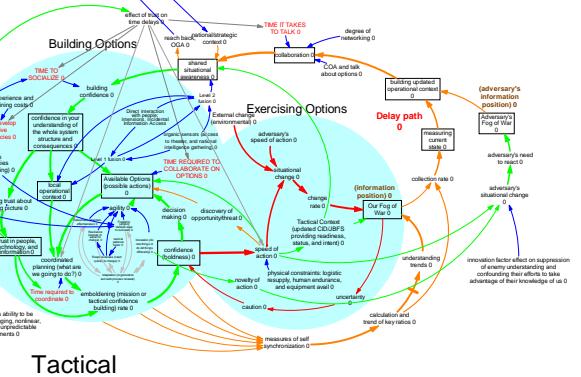


Theater Strategic



Operational

Insight: The agility of the operating units requires an agility within the command structure so that Ops Tempo can be matched with Battle Rhythm



Observation: Each layer has a unique balance between building and exercising options

Discovery: This dictates differences in time delays to perform a function

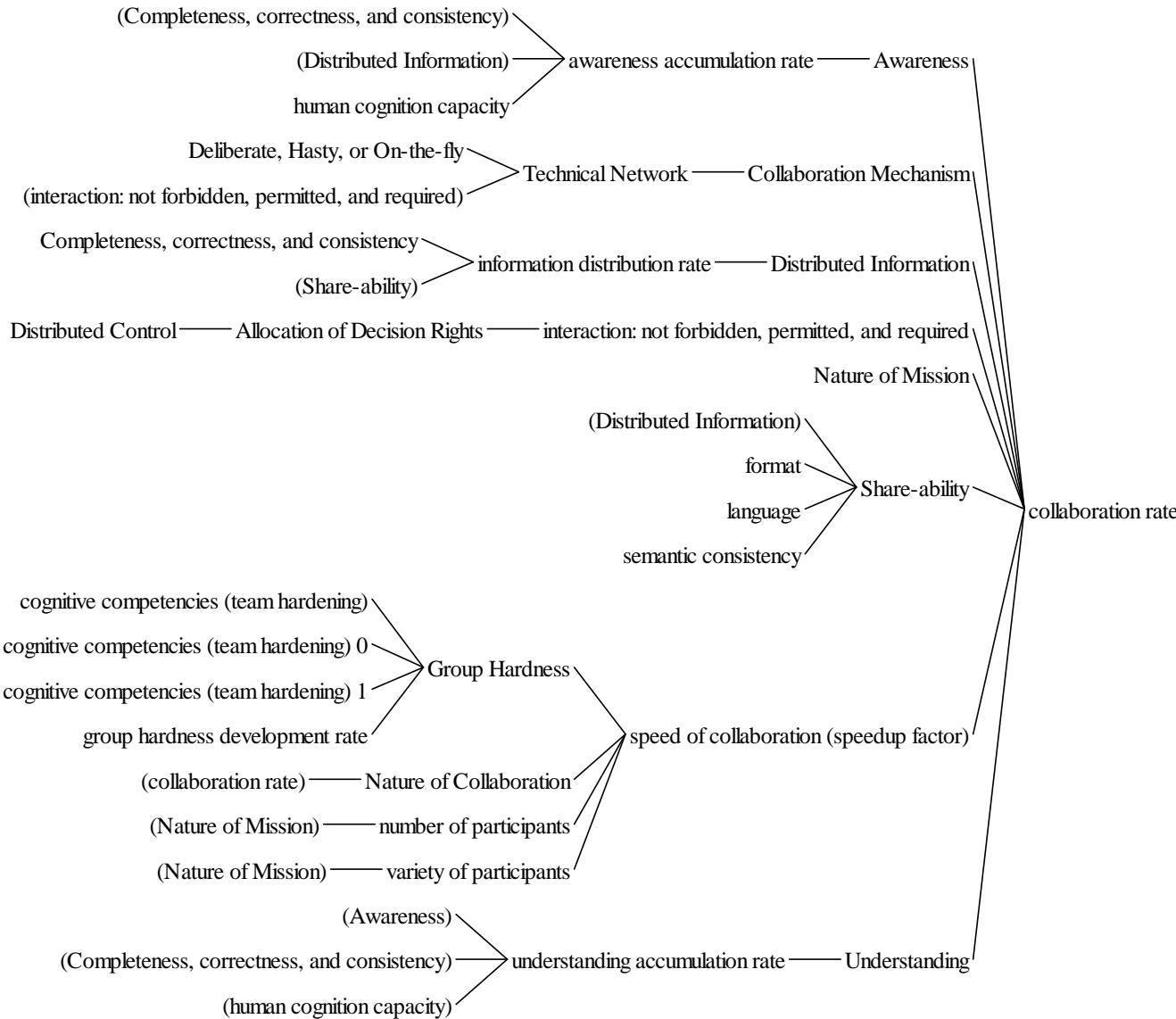
Insight: To maintain momentum, the regeneration of options becomes the constraint

Connectivity and Influence Analysis



Boeing Technology | Phantom Works

NCO Op's Analysis



Connectivity and Influence Analysis



Boeing Technology | Phantom Works

NCO Op's Analysis

